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THE Biologist



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in the
Biological Sciences

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Robert W. Pennak Receives Honorary Membership in Phi Sigma



DR. ROBERT W. PENNAK, Professor of Biology at the University of Colorado, has been awarded Honorary Membership in Phi Sigma Society by unanimous vote of The Council. Dr. Pennak was nominated for Honorary Membership by Alpha Pi Chapter on the basis of his national eminence in the field of biology, his administrative and academic services at the University of Colorado, and his conscientious efforts in Chapter activities. At the present time he is serving as Alpha Pi's Council Representative and Chapter Advisor. His national and international reputation is evidenced by his many accomplishments in the field of aquatic biology.

Dr. Pennak received his undergraduate and graduate training at the University of Wisconsin, receiving his Ph.D. degree from that institution in 1938. He came to the University of Colorado as an Instructor in Biology in 1938, and attained the rank of Professor of Biology in 1949. During his years of service at the University, he has directed 26 graduate theses, served on many University committees, and served as Acting Dean of the Graduate School, as well as Acting Head of the Department of Biology, at various times.

Dr. Pennak is the author of some 54 publications on biological subjects, including his well-known *Fresh-water Invertebrates of the United States* (1953) and *Dictionary of Zoology* (in press). His current research interests include microfossils and radiocarbon dating of Colorado mountain lake sediments, the comparative limnology of Colorado mountain lakes, and structure of littoral zooplankton communities, and the ecology of marine beach microfaunas.

In addition to his many teaching and research activities, Dr. Pennak is serving on the editorial boards of such journals as *Ecology*, *American Midland Naturalist*, *Systematic Zoology*, and *Transactions of the American Microscopical Society*. He has held the office of President of the American Microscopical Society and the Colorado Chapter of Sigma Xi, and has served as Vice-president of the American Microscopical Society and the American Society of Limnology and Oceanography. He is presently a member of the Executive Committee of the American Microscopical Society, a member of the Research Advisory Board for Lerner Marine Laboratory

at Bimini, British West Indies, and a National Visiting High-School Lecturer for the AIBS. He is a member of 12 national and international biological societies.

Dr. Pennak's Honorary Membership is the first such membership to be conferred upon a member of Alpha Pi Chapter. Formal initiation ceremonies will be held sometime during the spring semester of 1961.—Eugene H. Schmitz, Alpha Pi Chapter.

Space for Research

FRED N. ZEINER

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THE BEGINNING research student sometimes is unsure of his choice of field of specialization. Choice rests upon a variety of interrelated factors such as basic interest, undergraduate background, associations with other students and with faculty, future opportunities in the field and available facilities. The latter may often be directly related to interests of available faculty.

Although room for new research is abundant in all biological specialties, it is sometimes thought that the cream may have been skimmed from well-known fields. Here, opportunities are more apt to be found through close association with those well established, or as a result of the development of new techniques or instrumentation in allied areas. New fields, however, offer greater challenges and rewards to the person just starting his research career.

Space biology is an exciting new area of interest in which both theoretical and practical problems exist in profusion. The nature of biological response to certain environmental situations known to exist in space must be determined. Unknowns of the space environment will increase the list of fascinating possibilities. Not only will such investigations add much to our fund of basic knowledge, but also they will necessitate revisions of current beliefs. The fine work in many laboratories already has illustrated the points above.

Engineering is rapidly making available the hardware for putting man into space. The biologist has the responsibility of keeping him alive while he is away from the extremely special environment in which he has evolved. Some problems are restricted to atmospheric traverse, others are found both during traverse and in space habitation; the latter add up to human ecology that is complicated by practical engineering considerations. It is the intent here to illustrate many problems, but to do so with a minimum of detail. The zoologist specializing in areas other than mine, the botanist and the psychologist will recognize parallel problems and opportunities in their own fields.

Man will be confined to a sealed capsule in space, whether it be a

"space-suit" or much more roomy quarters. Since the space environment is hostile, the apparent solution is to take his normal environment with him in this capsule. We know much of the normal environment; engineering dictates that economies be made, however. The physiologist must determine environmental minimums to ease the problem of supply. Perhaps it would be better to describe this as a determination of the maximum allowable deviations from normal. The adaptability of the human body is, of course, a part of this question and must be determined.

Certain problems are restricted to atmospheric traverse. There is tremendous acceleration with the blast-off and with emergency ejection of crew in the event of malfunction; deceleration occurs with power cut-off, atmospheric re-entry and landing impact. Much work has been done here with force/time relationships and human tolerances. Human tolerance to noise is a definite factor, but insulation from the noise of engines and aerodynamic buffeting is readily accomplished. Bioengineering has solved most of the problems arising from the aerodynamic heating of speedy atmospheric transit. A possible trouble-maker is the aerodynamic vibration of the space vehicle in atmospheric traverse. A vibration frequency to produce resonance of the viscera of the astronaut could be uncomfortable, perhaps fatal. Time of exposure is critical. Much work is indicated in this area.

Many of the following problems are common to atmospheric traverse and to true space habitation, but emphasis will be placed on the latter. The time factor is important both biologically and logistically in many cases. The two most knotty problems are those associated with the weightless state and with radiation.

Much is known of the biological effects of radiation. This is true in regard to both individual well-being and to future generations. To be sure, we should know more of the effects of very low-level radiation upon large segments of the world's population and of the results of cosmic rays and hard X rays. The major gap in our knowledge, however, is what amount of ionizing radiation to expect in space. Knowledge of the Van Allen belts helps, but what is the exact level of radiation therein, and how much does it fluctuate from hour-to-hour, day-to-day, month-to-month? And even then, this is the mere doorstep to space. Of course we do not want to break our necks on our own front doorsteps, so we can use the polar routes for exit and re-entry, but we know very little of radiation in true space. Each space probe gives us more information. Since all information suggests much radiation, how is the astronaut to be protected? Twelve inches of lead is not practical!

Our ignorance makes the effects of zero gravity the greatest unknown of space biology. The reason is simply our inability to negate the effects of gravity in the laboratory. Changing direction of normal gravitational force may at least give us hints as to what to expect in the weightless state. Areas in which lack of gravity is known to have effects, or where effects might be expected, will be mentioned in hopes this will lead to critical research that will provide precise answers.

Body orientation is brought about by means of the vestibular apparatus, the mechano-receptors, and vision. Although people vary considerably in susceptibility, motion sickness is a distinct possibility whenever more than one of these factors is disturbed. The vestibular apparatus and the mechano-receptors cannot act normally in the weightless state; the visual factor in orientation in the horizonless void of space will be handicapped. The need of methods for selecting those least susceptible to motion sickness and for training procedures to reduce this effect is obvious.

The normal function of various epithelia of the body includes ciliary activity. It is not known if cilia will perform properly in the absence of gravity. Of most concern here are the respiratory passages. If ciliary activity is inhibited, movement of mucus (and any foreign material it has entrapped) to the exterior will cease. Such failure of ciliary propulsion would lead rapidly to pulmonary congestion and fatal pneumonia. Manned space-flight without provision for artificial gravity (an engineering headache) would be impossible! Lesser evils, e.g., clearing nasal sinuses, could be mentioned.

Ingestion of solid food poses no problems. Liquid intake presents a puzzle of a mechanical nature. One could not drink normally from a glass as the momentum conveyed to the liquid in raising the glass to the lips would slosh the contents into the face. The danger of pulmonary aspiration would exist as it would also, because of a poor liquid-gas phase separation, in using a straw.

In early space explorations, the astronaut will need to wear a confining space-suit as a protective measure, should the pressurization of his meager cabin fail. This will limit seriously the time span of such flights because of the need of defecation. In the shirt-sleeve environment of a larger and safer cabin this will be no problem, since weightlessness does not affect the appropriate physiologic mechanisms. Of more concern is the problem of urination under conditions of zero gravity. It has been found in brief exposures to near weightlessness attained through parabolic flight patterns in high-performance aircraft that voiding is difficult for all and, apparently, impossible for about 25 percent of the subjects. The other 75

percent can be trained, but there is indicated an area requiring the biologist to determine good methods of selection and of training for potential astronauts. It is of interest that this work on lack of gravity is showing the need of revisions of our ideas of the mechanism of micturition; other fundamental concepts of physiology may well need revision as weightlessness receives further study.

The astronaut will have to re-learn to some extent how to make familiar movements and perform usual chores, since use of muscles during weightlessness will be much different from normal. In prolonged space habitation, muscular atrophy similar to that resulting from long confinement to bed will occur unless definite measures in the way of exercise are taken to prevent it. Another easily solved effect of weightlessness is the lack of convection currents. Without air circulation a person would re-breathe his expired respiratory gases and sweating could not accomplish its purpose. The circulatory system has such wide adaptability that it should easily be able to compensate for the lack of vascular hydrostatic pressure in space.

Difficulty of maintaining a habitable atmosphere in the sealed capsule is directly related to time and is largely a matter of logistics. The amount of oxygen required by the crew and other living organisms and the quantity of carbon dioxide they will produce can be calculated. Although the partial pressure of oxygen available is of prime importance, rather than the percentage of oxygen in a mixture, the two are obviously related. At first glance it would seem economical to increase the percentage of oxygen to 100 to allow lowering of the total pressure to 20 percent of normal. This would reduce strength requirements of the gas-tight chamber and remove the need of providing an inert gas. Although the accompanying weight reduction would be desirable, the fire risk would be prohibitive and evidence of toxicity is seen when high percentages of oxygen are breathed for prolonged periods. It is not known how much the air can be enriched with added oxygen before toxic effects will be seen after long exposure, nor is it known if nitrogen is the ideal diluent. The submariner can contribute much information concerning oxygen supply and of removal of carbon dioxide and noxious odors and gases, but restrictions of weight and volume of supplies and equipment are much less severe for him.

The theoretical knowledge of nutritional requirements, both quantitative and qualitative, is available. Careful planning is required in order to keep the weight of supplies of food and water to a minimum and yet allow a margin of safety. There will be no supermarkets handy in space! A search for foods of high nutritional value per unit of weight is indicated.

An efficient means for disposal of excrement must be devised. Temperature control can be accomplished easily when the following questions have received answers. What is the heat production of each of the living organisms in the capsule? How much heat will be given off by the equipment of the capsule? What radiant heating of the capsule will occur and what amount of heat loss to space can be expected?

However well the crew is protected from direct ionizing radiation, it is likely that the air available to them will be ionized. Does ionized air have any biological effects? If so, do positive ions produce effects different from negative ions?

A problem of crew selection was mentioned previously in discussing motion sickness. A few additional facets of crew selection should be considered. There has been seen evidence of what is called "space myopia," a sort of visual hypnosis, in the void of space. With no normal landmarks or horizon, judgment of distance and speed is much impaired. Do people differ in their susceptibility and how can this be determined? The astronaut will need to possess a high degree of psychological stability. Isolation from all things known and familiar on earth with an accompanying sense of loneliness will be a heavy burden. Confinement in close quarters with other crew members for prolonged periods and with the inherent dangers of early space exploration will raise tensions. In the early days of the western mountains, prospectors confined to small cabins during severe winters often experienced "cabin fever"; blood-shed between the best of friends frequently resulted. Crew selection will help in preventing such unfortunate situations. Both the living conditions and the nature of the work of the astronaut will be stressful. It would be helpful if it were possible to select those least susceptible before the blast-off. It would be desirable also to find a stress response that could be used as a "strain-gauge" in space travel of long duration. Should the man at the controls of the space vehicle show evidence of increasing stress, his copilot could then take over before damage to man or mission resulted. An ideal indicator should be dependable and objective and show a magnitude of variation from the non-stressed to the stressed situation sufficient so that the reading is obvious. The limitations of space, facilities and time in a sealed capsule must be considered. The proper usage of the indicator should require little training on the part of crew members. It should be applicable to stress resulting from low-level, but long-term stimulation. Ideally, the presence of an undesirable stress condition should be indicated prior to performance decrement. The less standardization of the individual required, the better.

The astronautical engineer is constantly seeking means of reducing weight of the pay load he is asked to propel beyond the earth's gravitational attraction. In previous paragraphs weight control of biological necessities has been mentioned, as has been the matter of duration of flight; and, of course, the relationship of these factors is obvious. It is in this connection that the ecologist must play an important part.

In flight of relatively short duration it will be easy enough to take along enough oxygen, water, and cans of beans to sustain life. As duration of flight increases (or with the establishment of manned bases elsewhere), the problem of getting such a load beyond the earth's gravity becomes very great. Eventually the weight of consumable supplies will exceed the ability of the engines to get it under way. The obvious solution is to take along a balanced, self-sufficient, re-cycling ecosystem which will produce its own food and oxygen by utilizing the metabolic wastes of the astronauts. As on earth the power supply will be that of photosynthesis. The ecologist must design such a system, but one that is compatible with the engineering requirements of space flight—a large order. Such a system would seem to preclude satisfaction of weight requirements; at best it would represent a very heavy load. However, current progress on such a system and on propulsion has led to a compromise estimate that, in spite of launching difficulties, flight beyond 35 days duration will be more feasible with a balanced ecosystem than it would be if only consumables were taken. If the suggestion of 35-day flights seems fantastic, remember that a round-trip to Mars will take about 60 days and a manned base on the moon might be maintained for years. The basic research needed for such practical applications must be started years in advance.

What meat animals exist or can be developed for space flight that have a minimum of waste and a maximum of edible flesh, and that yield a maximum of edible components for a minimum of food intake and do so in a minimum time? The same considerations hold for edible plants.

Astronomers claim there are uncounted numbers of planets on which conditions suitable for life as we know it must exist. In this case, the possibilities of biological exploration are infinite. Various theories have been presented as to the physico-chemical environment that must have existed on the earth at the time of origin of the first living entities, and which was a requisite for their origin. Perhaps similar conditions will be found in other solar systems; if so, we could learn much concerning this all-important phenomenon. The biological possibilities of space exploration seem to be as infinite as space itself. Let's help the engineers to get us there!

Emphasis has been placed on the human factor, because man is going into space and well within our lifetime. Of course much will be learned, as in all of physiology, through prior usage of experimental animals. They will be the first to occupy exploratory orbiting vehicles. There are many problems. Not all have been mentioned and most have been over-simplified. All are under active investigation in at least some of their ramifications and partial solutions are available in most cases. The adaptability of man, both physiologically, but more particularly because of his intelligence, will reduce the size of many of the problems as he meets them head-on in actual space. At the very least, space biology is a fertile and fascinating field for research in many areas.

In conclusion, I believe we as scientists should be concerned with more than the technical aspects of manned space flight. For one thing let us hope that pressure to get a man into space, purely for purposes of propaganda, will not force this country to put him there prematurely. Let us first be sure we can keep him alive. Secondly, is the world prepared sociologically for the implications of space exploration and colonization? Perhaps we have here a parallel with the atomic bomb. Science was able to produce the hardware, but world citizenry was too underdeveloped sociologically to handle it.

Suggested Reading: *Aerospace Medicine* (Formerly the *Journal of Aviation Medicine*) is the best single source for keeping posted in this area.

TERMITE QUEEN

Once a queen I may have flown
And known a world of light?
Yet here as imprisoned worm on a throne,
Prone in tunnelled night,
Deafened by shrill subsonic drone,
I do not dream of flight.

Vera Koehring
Hunter College

The Philippine Nuclear Reactor and Biological Research¹

PAULINO J. GARCIA

Chairman, National Science Development Board, Manila, Philippines

I THANK the officers and members of your society for this opportunity of sharing some thoughts with you. This group, I understand, is composed of men and women whose prime interest is the study of life through the rapidly expanding field of biology. It is therefore a propitious occasion for a brief discussion of the vast opportunities for the advancement of biological research in the Philippines to be made possible by the forthcoming Philippine Atomic Research Center.

Following the classic literary dictum of going *in medias res* at once, I shall launch into my discussion of the subject immediately by announcing—with a certain amount of jubilation—that the first nuclear research center of the country will be inaugurated next year. This will make it possible for our scientists to utilize the versatile powers of atomic energy in pure and applied research. The center will be operated by the Philippine Atomic Energy Commission which is charged with the execution of the country's nuclear energy program.

The reactor will be a donation of the United States government. The parts are now being manufactured in the General Electric Plant in San Jose, California, and the first components will arrive in Manila shortly. According to schedule, the reactor will be fully installed and ready for use by the middle of 1961.

Our proposed research reactor will be different from the so-called power reactor which supplies heat and electricity for industry in countries threatened with a growing shortage of oil, coal and gas. The primary uses of the research reactor is as a source of radiation for important biological and engineering experiments and as a device for producing radioisotopes. The use of radioisotopes is definitely one of the most dramatic achievements of modern science. They are extremely helpful in unlocking the mysteries of nature and increasing man's control over his en-

¹ Delivered on the occasion of the Eleventh Anniversary Banquet and Initiation Rites of the Alpha Chi Chapter, Phi Sigma Biological Honor Society, April 2, 1960.

vironment. Radioisotopes serve as sources of radiation, and as such they are utilized in much the same way as radium and X rays. They may be used in radiation therapy for cancer patients, in irradiating plastic material to change its properties or a sack of potatoes to prevent spoilage, in testing industrial materials, and so forth.

Besides serving as simple sources of radiation, radioisotopes can be tremendously helpful in research as tracers. As such, they reveal the complicated course of batches of atoms in physical transfers or in chemical or biological reactions. This has been the most important use of radioisotopes. Radioisotopes are incorporated into the material which may be water running through a pipe, sugar being utilized in a human being, a raw product for milk production in a cow's body, or an atom transferring from one kind of molecule to another in a chemical reaction.

Radioisotopes permit materials to be traced in minute quantities. Radiation from isotopes diluted with an unbelievably immense quantity of non-radioactive material can easily be detected. It is possible to trace one-tenthousandth of a milligram of radioactive material dispersed, say, in a 500-kilogram carabao.

Even more important than sensitivity is the specificity of radioisotopes. They can label a specific batch of atoms whose course can be traced through a series of chemical or physical processes in spite of multiple reactions with numerous other atoms or molecules. This permits the sorting out and untangling of complicated processes which can be accomplished in no other way. The sensitivity of radioisotope detection, the specificity of the tracer-method, and their unique radiation characteristics permit radioisotopes to be used as powerful analytical tools where standard methods of analysis are not satisfactory, as in the determination of minor elements in animal tissues, garden products, and minerals.

In medical research, radioisotope tracers are being widely used in the study of body metabolism. For example, the radiotracer studies in the past showed that nearly 90 per cent of injected calcium concentrated in the bones of young animals, and that in the older animals the uptake was about 40 per cent only. Tracer techniques are also being employed in determining the fate and action of drugs or of compounds being tested for possible effectiveness against diseases, particularly cancer.

As a source of ionizing radiation, radioisotopes affect living organisms. A great deal of effort is being devoted to studies of animal and plant life exposed to radiation.

In agriculture atomic energy is creating far-reaching changes. Radioisotopes offer in this field a unique tool with which to unlock the secrets

of plant and animal life and to combat the scourges that destroy it. Both as tracers and as sources of ionizing radiation, they are being used in crop and animal improvement and in pest control.

The most dramatic progress in crop improvement is the phenomenon of radiation-induced mutation. Natural mutation, as everyone knows, goes on spontaneously but at a very slow rate. Radiation hastens its occurrence. While radiation-induced mutation does not offer a short-cut to crop improvement, since most mutants produced are undesirable, there have been results that promise new strains of hardy disease-resistant plants. One of the most spectacular results reported is the development of rust-resistant oats after only one and a half years of work. It is estimated that conventional breeding methods might have taken 10 years to produce this result.

Disease-resistant plants are by no means the only successful results of mutation through irradiation. Peanuts and other plants have been developed which have higher yield and a size and shape better adapted to modern methods of harvesting.

Another promising benefit of radiation-induced mutation is the preview of future plant diseases that it makes possible. The degree to which plant disease can be overcome depends a great deal on how well possible future diseases are understood. The hastening of mutations in disease fungus and other plant scourges, which otherwise would take years, enables us to gain in advance a knowledge of what types of new diseases may occur naturally in the future. The importance of this is at once obvious. Strange as it may seem, this phenomenon will enable us to prepare now against diseases that are bound to confront our agriculture many years hence.

Before the use of radioisotopes, tracing the different elements through living plants was impossible. Today the mysteries of metabolism and translocation are being unlocked. With the help of tracer atoms, the path, rate of entry, and movement and the transfer of ions from the environment to the plant cells are being revealed. For example, by means of this investigation, it has been found that although calcium is absorbed in the plant by both the fruit and roots, absorption by the roots alone is not sufficient for fruit development.

Studies in fertilizer uptake of plants with the use of radioisotopes are yielding valuable information on the efficiency of different fertilizers, the types best suited to various plants, and the most economical ways of applying them. Through the use of isotopes, it has been proved conclusively that plants absorb nutrients not only through the roots but through the

foliage, the fruits, the twigs, the trunk and even the flowers, and that certain plant nutrients are absorbed more efficiently by certain parts of the plant than by others.

The secret of photosynthesis is being unraveled and a better understanding of root systems and their rate of growth is being gained.

Likewise, the fight against destructive insects is being advanced. The screw worm flies, for instance, have been exterminated in a Caribbean island (Curacao) by sterilizing large numbers of male flies. Thus, by a series of events too complicated to detail here, the population of this insect was reduced every succeeding generation until the species was exterminated in that island. Furthermore, the development of considerably more efficient insecticides has been made possible through studies utilizing radioisotopes.

I could go on indefinitely citing other biological studies utilizing the versatile radioisotopes, which are fast yielding a wealth of new knowledge and insight into the vital processes of plant and animal life. This is not to awe you with the impressive progress being achieved by biologists as a result of splitting the atom but only to apprise you of the vast new frontiers that lie ahead for us.

In a predominantly agricultural country like the Philippines, the biologist is faced with tremendous and challenging tasks. Our agricultural crops are attacked by many destructive pests and diseases. The coconut disease called cadang-cadang and the abaca mosaic are responsible for the loss of millions of pesos every year. Conventional methods of investigation do not seem to provide fast enough the essential information necessary for their control and total eradication. It is for this reason that the Atomic Energy Research Center is placing top priority on the cadang-cadang menace, among other pressing agricultural problems, in its research and development program. Our fisheries, to cite another field where great scientific strides can be achieved, will benefit considerably from the utilization of radiotracers. Our fisheries resources are among the richest in the world but they are bound to be depleted if we do not expand our knowledge of fish life, distribution and fisheries techniques. These are areas where the use of radioisotopes find important application.

As I said in the beginning, our nuclear reactor will start operations or, in reactor language, will "go critical," next year. It will, for all purposes, mark the beginning of the age of nuclear energy in the Philippines. To prepare for the foreseeable rapid growth of nuclear science in our country, the University of the Philippines and some private universities are now offering courses in nuclear science, and the Philippine Atomic Energy Commission has also opened a series of special courses in radioisotope tech-

nique. The latter is patterned after the courses conducted at the Oak Ridge Institute of Nuclear Studies in Tennessee and focuses training on the basic principles of nuclear chemistry and radiation physics and in the use of radioisotopes as a research tool in biology, medicine, industry and agriculture.

The nuclear research reactor will rise as the symbol of our country's great hope for the future. It will help not only in pushing back the frontiers of scientific knowledge but also in accelerating the country's economic growth. Indeed, the reactor will represent our determination to give our people a better, richer and fuller life through the blessings of modern science.

Complacency in the Population Crisis

T. H. FRAZZETTA

Department of Zoology, University of Washington

NEVER BEFORE, at any time in man's history, has the increase in human numbers been so rapid as it is at this very moment. Tomorrow's rate of increase will be even greater than today's. Overcrowding, starvation, depletion of resources, and the rapid shrinkage of living space are major characteristics of today's world.

By 1975, assuming present reproductive rates, India can expect 146 million more people, Mexico's population may increase by 56 per cent of its present level, and the United States must provide for 38 million more living beings.¹ It is this last named country which is to be discussed. I have selected it because I live in it, and am therefore personally concerned about its future. This is not to suggest that we ignore the desperate situations existing elsewhere on the globe, but instead to emphasize that the rather popular American view that pressing problems are the exclusive property of *foreign* nations is a kind of escapism that should be discouraged. In fact, the population picture, as it applies to the United States, is much more imposing than most persons imagine. From a consideration of size increase, it appears that the "United States is the second or third fastest growing nation in the world."¹ The per annum increase is now over 3 million, and is equivalent to multiplying the present population of Seattle, Washington, by a factor of 5 or so each year. And there is no significant change in sight.

As a nation, we are a long way from starving. At the present time we are actually burdened with the problem of excess food. It might seem that any present worries over possible starvation are sheer illusion, but, as the population continues to increase, food must also be made available in larger and larger quantities. Even with improved techniques, it is unlikely that future land agriculture will become so efficient that we should expect the rate of food production to parallel the fast rising growth curve of human numbers. Algae farming, synthetics, and other more efficiently produced foods will have to be depended upon if the present population trend continues. A change in our diets from the customary bill of fare to less appetizing alternatives may someday be a necessity. It is of

but minor comfort to the thoughtful person that this change is still years away. With continued population growth, such as we have had in the last decade and a half, our food surplus will vanish and our dependency on imports or more efficiently produced nutrients is expected to increase, all within the next lifetime.

Other resources present a similar problem. In order to maintain present living standards, consumption, and, therefore, development of resources must increase at least as fast as does the population. New synthetic materials may substitute for depleted stocks of non-renewable items, but they themselves are, of course, derived from other resources. Also, many materials will perhaps never be synthesized, and adequate substitutes may never appear. Increasing demands for living space will make more and more difficult the cultivation and development of many renewable resources. As resources become less abundant, methods of extracting them become more inefficient; a higher technology is required to make them available. This, in turn, depends more heavily on the stability of the economy and the general technological progress of the country, and will be more sensitive to upsets, however slight, than are preexisting methods. It is unlikely that an economy laboring under such increasingly stringent conditions could persist for long without tightening government controls on business, individual liberties, and so on. Even at that, it could not continue indefinitely since limiting factors would be gaining in abundance. The reader is referred to Harrison Brown's recent book² for a detailed discussion of technological needs and realities.

So far I have mentioned briefly the resources and food problems of a kind already affecting the poor countries, as it will, in time, apply to the United States or, for that matter, any nation with runaway population growth. I have omitted mention, up to this point, of a resource which is not only of unestimatable importance, but which can never be synthesized. Not only is our living standard dependent upon it, but our outlook as a nation of individuals would become hopelessly mutilated without it. This resource is living space. And we do not have to look far into the future to see its extinction. We are already losing it at a prodigious rate.

Living space relates to our territorial rights as individuals. Our needs in this regard vary with individual temperaments. For example, a person of esthetic or thoughtful turn of mind might well be expected to have a greater regard for privacy than would another without such attributes. Each person makes definite demands on space in terms of housing facilities, roadways, classrooms, recreation areas, and almost anything else

that can be named. Overcrowding reduces the individual's freedom, confining him within narrower and narrower limits of acceptable behavior, and violates his opportunity to live a freer and, therefore, a richer life. Decreasing privacy, with a consequent increase in social pressures, easily leads to the submergence of the intellect, and, beyond, to boredom and flimsy social values. Congestion has been an uncommon problem in this country, and we Americans have enjoyed a life of such high quality and freedom that we have become the envy of the world. However, congestion is already becoming a common condition in an alarmingly great number of densely populated areas. Poorly planned, inadequately spaced housing developments are almost becoming a national symbol. Great cities are overflowing, meeting, and creating ever-growing belts of congestion. Their limits are becoming indefinable. A few years ago, a person living in the heart of Manhattan could free himself from his noisy and crowded entanglements by a drive across either the George Washington or Triborough Bridge. Today, the city sprawls awkwardly into Long Island, Westchester, and nearby New Jersey. The modern Manhattanite is now literally imprisoned, but probably, in many instances, has strived to forget the better days and has made unconscious adjustments to a somewhat less appealing life.

Is life in the neighboring suburbs any better? Social scientists are discovering that these broad, monotonous expanses of similar dwellings contain, for the most part, monotonous and similar people, drowned in a welter of stereotyped ideals, and whose horizons extend no further than the picture window across the street. These people too are trapped—living space has become as inaccessible to them as it has to the urbanite. Like it or not, they are forced to cling together in their expansive, outlandish communities, for there is little place else for them to go.

Thankfully, not all of America has succumbed to the Levittowns and similar projects. But "suburbia" is a brutally expressive example of a very definite trend.

The question of how many people can be supported on a subsistence basis appears much less meaningful than a great many other population questions that could and should be asked. If we allow ourselves to become so overpopulated that confinement becomes the rule, that concentration on the single task of staying alive becomes life's sole enterprise, what really is there to live for? We can continue as we are doing up to the point where life is a miserable, meaningless, metabolic activity, and still we will have to stop the human increase sometime or physically perish. Is there any intelligent purpose to seeing how much the earth (and humanity as

well) can endure? Though the experts can, if necessary, find ways to support large populations on a subsistence basis, "in no expert's view of how life can be supported in the future, with unlimited population growth, is there an appealing picture of the quality of life."³

If the situation is as distressing as all this, why are so comparatively few people worrying about it? Why is there such a general reluctance to acknowledge the problem? At this time, only a minority of individuals appear to have an adequate appreciation of its gravity. However, the members of this fraction of the citizenry are, in many instances, individuals who are best able to evaluate the nature of the problem. Physicists, mathematicians, biologists, chemists, demographers and other scientists are well represented. The books and articles listed in the abbreviated bibliography contain a sampling of views on the problem as seen through the eyes of important authorities. To this list, the interested (or, in view of the urgency of the situation, should I say the "conscientious") reader is referred. Nevertheless, it is pertinent here to cite the views of a population specialist. Bogue, in his voluminous and comprehensive analysis of the population of the United States,¹ has this to say: "Feature writers in our Sunday newspapers and magazines often talk about the 'population explosions' in Japan, India, China, and many other 'underdeveloped' countries of the world. Actually, under current trends, the United States is exhibiting one of the worlds greatest numerical increases. It is potentially able to make one of the biggest bangs when the population bombs go off."

The remainder and, alarmingly, the majority of the populace is quite unmoved. Probably most people have never thought about the problem because American resources and living space have always been in such generous abundance that it is difficult to conceive of their annihilation. Even when adverse effects of population pressures are felt, their proper identity is not always obvious. More pertinent yet is the fact that the consequences and conditions resulting from a high birth rate are not wholly apparent until 20 or 30 years after the births have occurred. Even if, overnight, the birth rate leveled off to replacement values, that is, to an average of two offspring per couple, the situation a generation from now would be severely critical. If the solution is too long in the coming, there will be very little worth rescuing. The importance of recognizing and facing this not too pleasant fact is underlined by many experts, including D. J. Bogue who warns that, if present reproductive rates continue, the terrific population expansion which this country is now experiencing will be nothing but the "starting point" for such an unbelievably rampant increase that present trends will be dwarfed in comparison.

Some of the probable factors underlying the general lack of public responsiveness to the crisis have been mentioned in the preceding paragraphs. There are, however, forces of active suppression at work as well. The American businessman is one such. Profits loom large in his eyes, at least for the immediate future, with each new potential consumer. He has attempted to establish the myth that living standards for all are rising as a direct result of the staggering birth rate. Though some economists lend support to this belief, other do not, and hardly any contend that we can hold the economy together indefinitely if population growth continues. Spengler points out that the United States economy is growing despite the population growth and not because of it, and that rapid human increases tend to inhibit economic attainments.⁴ And Bogue sums up his views in these words: "A look at other times and other places fails to confirm the easy credo that a pure increase in numbers brings prosperity. There is no high correlation between level of material comfort and reproductivity, even among the technologically well-developed nations where private enterprise is the preferred mode of life. One need look no farther than the Netherlands or Italy to learn that runaway population growth is regarded as an enemy of high per capita real income, and of profit on business investments. *Why should it be different in the United States in the long run?*"

There is little doubt that the most important agents which are energetically trying to barter complacency for concern are those certain religions which are opposed to family planning. With great success, they have managed to keep the issues well nigh out of sight, exhibiting them only in the garb of a theological, rather than a social, scientific, economic, and world issue. I do not intend to embarrass *The Biologist* by immersing it in a religious controversy, but such matters must be discussed, rather than dismissed, if we are to arrive at a cogent evaluation of the causes of public indifference regarding populations.

According to certain religious doctrines, any type of planned control of an individual's reproductive rate is "sinful." Justification for the campaign against birth control is usually sought in the perennial "natural" versus "unnatural" argument, though what is "natural" with regard to human behavior has never been, indeed, can never be, defined by these religions. In fact, disapproval of birth control stems not from any logically argued basis, as is frequently pretended, but from church traditions and doctrines. The reader is referred to Zimmerman's recent book⁵ for a presentation of one religion's view of populations. Here, as is the case elsewhere, a Catholic writer recommends every imaginable solution except the obvious one. Emigration is stressed, as it frequently is, suggesting, I presume, that coun-

tries still without a population problem should welcome irresponsible procreators from elsewhere. This book, however, does spare us the nonsense of emigration to outer space, though other Catholics have been desperate enough for a solution to propose it seriously. Hardin's short but pointed article⁶ on this subject should serve to dispel any unfounded notions along these lines.

Zimmerman does not countenance birth control, even for Japan, a country which he himself admits is already sorely pressed. One should take particular note that he really admits (though these admissions are disguised and hard to find) that no genuine solution to the population problem exists in any of his proposals: "The space of the earth is limited and cannot accommodate a race which expands forever. Therefore, according to our present knowledge, we cannot understand how God intends to maintain the state of equilibrium." Although such honesty from a Catholic writer is refreshing, one cannot but wonder why that author bothered to write a book in the first place, which purports, in many places, to deal with the problem on a basis of rationality, rather than on one of faith.

I have tried, in the limited space allowed me, to highlight some of the causes of public complacency with respect to the negative effects of rapid population growth. Most readers of this article will be scientifically oriented persons. As such, they are in an exceptionally fine position to evaluate the problem, and perhaps encourage others to give it deserved attention.

Complacency is, however, one of the most dangerous aspects of the problem, since it is the major, if not the only, stumbling block. To quote Bogue once again, "Our common sense tells us that a people with enough acumen to attain its present advantageous position would certainly do something about the threat of 'standing room only' population long before it became critical. However, as has just been illustrated, the full impact of a reproductive increase is not felt until a quarter century or so later."

We must face up to the fact that population, like any other problem, must be approached realistically if it is to be dealt with successfully. Someday we will have to face up to it. Why not do it before human decency has irretrievably declined?

The situation is not yet beyond salvation. This is the hopeful facet of the problem, for it means that social depreciation need not be inevitable. But for this same reason, any failure on our part to seize the already fleeting opportunity will be all the more inexcusable. We face an awesome responsibility from which we cannot become disencumbered by intellectual lethargy. If today we fail to face the problem with energetic and unfettered

minds, then the terrible blame for the neglectful creation of a miserable and purposeless existence must be ours tomorrow.

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The Editor Speaks

Professor Thomas Park of the Department of Zoology, University of Chicago, has accepted the Honorary Presidency of the Phi Sigma Society. He succeeds Dr. Lawrence H. Snyder, who has held the position since 1953. Professor Park is an eminent ecologist specializing on population dynamics. Much of his work has been with the confused flour beetle, *Tribolium confusum* Duv.

Members and friends of Phi Sigma are congratulating our Executive Secretary-Treasurer, Fred Orcutt, on his appointment as Head of the Department of Biology at the Virginia Polytechnic Institute. He has been acting head of the Department since January 1958 and a member of the staff of Virginia Tech since 1936.

Elsewhere in this issue of *The Biologist*, Mr. T. H. Frazzetta presents a wide spread point of view of the dangers inherent in population increase in man. The purpose of this editorial is to suggest that matters may, after all, not be quite so serious as Mr. Frazzetta depicts. I believe, in effect, that humanity is sufficiently adaptable not to allow the population to rise to extreme levels. First, I point out that standards of living in no country have ever declined because of population increase. Secondly, at all periods of human history there have been certain sections of the population that have so modified their reproductive behavior as not to increase their numbers. In the third place, I suggest that, as present populations exert pressure on the food supply and living space and as certain social ideals spread an increasing portion of the populace will so modify its reproductive habits as to bring about population stability. Mr. Frazzetta's paper can be looked upon as promoting such social ideas.

Just as this issue of *The Biologist* goes to press the editor receives the Proceedings of the 1960 General Meeting of the Phi Sigma Society at Oklahoma City last August. The editor regrets his own inability to be present, but he was at the Eleventh International Congress of Entomology in Vienna at the same time. From these Proceedings we learn that Dr.

Henry van der Schalie, Professor of Zoology at the University of Michigan, was promoted from Vice President to President and Dr. Horton H. Hobbs, Jr., Professor of Biology at the University of Virginia, has been appointed Vice President. Dr. Hobbs is well known for his work on freshwater decapod Crustacea and since 1956 has been Director of the Mountain Lake Biological Station, Mountain Lake, Virginia.

Book Notices

T. H. Huxley: Scientist, Humanist and Educator. CYRIL BIBBY. 1960. Horizon Press, New York. 330 pp., 19 portraits. \$5.00.

This is not a conventional chronologically arranged biography, but a series of essays on various aspects of the life and thinking of this great English biologist. The details of Huxley's life are amply on record: a 2 volume *Life and Letters* (1900), the *Diary of the Voyage of the Rattlesnake* (1935), 5 volumes of *Scientific Memoirs*, 9 volumes of *Collected Essays*, and several biographies. Furthermore, as Dr. Bibby explains, "now that his scientific work has suffered the fate of all good research and been overlaid by its progeny, now that his controversial writings have become pieces to be admired for their elegant craftsmanship but no longer put to daily use, it is as an educator that T. H. Huxley has the greatest significance." Moreover, the author of this study is himself engaged in the professional preparation of teachers. The result is that the emphasis in this book is on Huxley's concern, mainly in the sixties and seventies, with public education and its reform in Great Britain. Huxley's biology is passed over lightly—one suspects that the author is no biologist. His defence of Darwin and evolution is noticed, but scarcely in depth. Huxley's anti-theological debates are treated somewhat more adequately, but his thoughts and activities in connection with improving education at all levels in Great Britain are described in relative detail. The treatment throughout is non-chronological, each chapter tending to range back and forth over Huxley's entire adult life. A significant contribution to the understanding of a great man.

Make Your Technical Writing Useful. WERNER O. NAGEL. American Fisheries Society, P. O. Box 483, McLean, Va. 31 pp. \$1.00.

A book of hints on writing a scientific paper. It won't make Steinbecks out of all of us, but it may be helpful.

The Nature of Science and Other Essays. DAVID GREENWOOD. 1959. Philosophical Library, New York. 95 pp. \$3.75.

A collection of five essays on the formal logic of science. Their titles: The Nature of Science, Concept Formation and Operational Definition, Quantitative Inductive Procedures, Causality and the Counterfactual Conditional, and The Problem of Real Numbers, indicate the volume's scope. Unfortunately, the book is printed in a type that is too small to make for easy continuous reading of an already sufficiently difficult subject.

A Dover Science Sampler. Edited by GEORGE BARKIN. 1959. Dover Publications, New York. 64 pages, illus. Free.

Everybody who reads science books is familiar with the notable series of reprints and originals issued by Dover Publications of 180 Varick Str., New York 14. The present brochure collects about 50 significant passages from nearly as many Dover books. These are extremely quotable paragraphs that will bring delight to both youngsters and oldsters in experiencing the adventure that is science. Of course, Dover hopes that users will be led to purchase one or more of the books from which the quotations are made and a form is provided for this purpose. But the brochure is worth while even though one does not venture beyond its own covers. So write in and get a copy without charge or obligation.

The Restless Atom. ALFRED ROMER. 1960. Doubleday & Co., Inc. Garden City, N. Y. 198 pp. 31 figs. 95¢.

This exciting addition to Doubleday Anchor Books tells the story of the experiments that gave birth to the study of radioactivity and nuclear physics. It extends from the discovery of X rays by Wilhelm Rontgen in Vienna in 1896 to 1912 when Niels Bohr left Ernst Rutherford's Manchester laboratory with the germs of the Bohr atom in his mind. The author feels that the way to explain physics is not to start with the fundamental laws, but that something can come of treating it as a natural science which grew out of experiments. In this spirit, the laboratory procedures and observations out of which the physics of radioactivity was born are related. We see Henri Becquerel, Pierre and Marie Curie, William Crookes, William Ramsay, J. J. Thomson, Hans Geiger and others at work in their laboratories and the momentous things that come of it—all without a formula or equation. There is a short list of suggested readings. Required reading for non-physicists, and even some physicists might discover from it how to make their subject more comprehensible to their audiences! The publishers should commission a similar study of biochemistry.

The Story of Chemistry. GEORG LOCKE-MANN. 1959. Philosophical Library, New York. 277 pp. \$4.75.

This is a *précis* of important names and discoveries in chemistry. In it the chemist or other interested persons can determine the dates, professional position, and important findings of the eminent chemists of the past and near past, but the book is hardly for continuous reading. There is an index, but the author is one of Germany's leading organic chemists, so that his view point is German.

The book exhibits considerable compression and it is only in discussing the great classical chemists in the middle of the book—Lockemann views Carl Wilhelm Scheele (1742-1786) as perhaps the all time greatest chemist—that actual biographical sketches of the men are provided. Alchemy is treated in the light of the modern critique of the anciently received accounts and a multitude of names fill the latter pages. No or

little attention is given to the cultural climate in which chemistry developed.

The history of chemistry is as important for an understanding of the history of biology as is chemistry itself for an understanding of biology, but this is scarcely the book to go to for such background.

Giants of Geology. CARROL LANE FENTON and MILDRED ADAMS FENTON. 1960. Doubleday & Co., Garden City, N. Y. 318 pp., illus. 95¢.

It is a truism that biology cannot live to itself alone. This is well recognized as regards its relation to physics and chemistry, but is equally true as regards geology. Not only is an integral subdivision of geology, namely paleontology, likewise an integral part of biology, but historical geology studies the environment in which living things have developed and during the 19th century evolution was as much a geological issue as a biological. Men such as Darwin and Agassiz and Dana worked in both fields. Books on the history of geology are, accordingly, of intimate biological interest.

The present paper back is a reprint (Dolphin Books) of a book published in 1952, which was in its turn a revised and enlarged edition of *The Story of the Great Geologists*, 1945. It consists of 23 swiftly moving chapters, most of them centered around the careers of one or two important geologists. Each chapter, moreover, is carefully documented, so that the reader is led to the biographical and other literature on which the book is based. The book thus serves as an easily read introduction to aspects of the history of geology. Two comments are in order.

(1) 12 of the 23 chapters (152 pp.) are devoted to the American scene, and scarcely any Continental geologists since Werner are noted, except Agassiz, who ended up American. However important British and American geologists have been since 1800, they have very far from constituted the entire geological picture.

(2) The accounts of some of the men are not too satisfactory. Such men as Lyell and Sedgwick and Agassiz cannot be adequately appraised without reference to their rela-

tion to the evolution issue and this the Fentons have not done very well.

If the partial nature of the Fentons' book is kept in mind, it can prove useful.

An Introduction to Animal Biology. Fifth Edition. DALE C. BRAUNGART and RITA BUDDEKE. 1960. C. V. Mosby Co., St. Louis. 416 pp. 213 figs. \$6.25.

This is an extremely simplified—perhaps over simplified—account of zoology for elementary college courses. The authors teach at the Catholic University of America, Washington, D. C. After a 19 page introduction we encounter the Protozoa and then, after another 12 pages of embryology and histology come the Porifera and 8 other phyla in "phylogenetic sequence," although the insertion of Echinodermata between Coelenterata and Platyhelminthes is not very good phylogeny. Multitudes of clear cut figures greet us and the careful user of the book will be familiar with much conventional zoology although he will hear nothing of numerous important animals. The mammal chapter (36 pages) is virtually confined to man, but without mention of human reproduction. The last two chapters treat genetics (29 pages) and evolution (8 pages). The influence of the authors' religion is shown by the fact that the only scientist whose portrait is included is Gregor Mendel and one wishes that theology as well as philosophy had been kept out of the discussion of evolution. On page 25 evolution is represented as one of the two great foundations of modern biology. In the concluding chapter, the attitude toward evolution is ambiguous. We are told (p. 366) that it is "*wholly beside the point*" (*italics mine*) whether the theory of natural selection is true; "it has no direct bearing on the theory of organic evolution considered as a question of fact." As further evidence of religious influence may be cited the discussion of the origin of the human races in terms of descent from Adam and the concluding sentence: "A scientific theory can logically be condemned when it is in direct opposition to revealed truth." This was the spirit that imprisoned Galileo and kept *The Origin of Species* out of the

Trinity College library at Cambridge University.

The Origin of Life on the Earth. Edited by A. I. OPARIN, R. L. M. SYNGE and others. 1959. Pergamon Press. New York. 691 pp. \$15.

Previous to the seventeenth century the origin of life was no problem. Anyone could see it continually arising on all sides. Then Redi about 1665 suggested that, on the macroscopic level, such originations were illusory and, 200 years later, while Darwin was suggesting that all living things may have evolved from a single ancestor, Pasteur and Tyndall showed that microorganisms no more arise spontaneously than do macroscopic forms. Astronomers and geologists, meanwhile, were clear that, at one time, the earth was devoid of living organisms, so that the problem of their origin arose.

The current aspect of the problem of the origin of life really dates, at least in English speaking lands, from the English translation of Academician A. I. Oparin's *Origin of Life* in 1936. The present hefty volume is the English-French-German edition of the Proceedings of the First International Symposium on the Origin of Life on the Earth held at Moscow 19–24 August 1957. The Russian language papers and proceedings have been rendered into English by Mrs. Ann Syngé, but the German and French papers (about 130 pages) have been left in those languages. The volume consists of about 60 contributions by about 50 or more authors with about 80 pages devoted to informal discussions. It represents an extremely elaborate treatment of its topic.

The first 175 pages or so deal with the primitive earth. Did it go through a hot phase which would have driven off the primitive atmosphere? To what extent is the O_2 in the atmosphere the product of photosynthetic organisms (probably very largely) and for how long (geologically) has CO_2 existed at the present low level? Not all the contributors agree and, since the various chapters are only very slightly dependent on those that go before, there is

some very helpful repetition of basic assumptions and hypotheses.

The latter chapters are more biochemical, and remind us that the problem of the origin of life is in great measure a biochemical one. The origin of dissymmetric molecules, the original formation of amino acids, the origin of the "fore-protein," the duplication of molecules in living organisms, and the evolution of enzymes are samples of the many topics treated. The actual artificial synthesis of living matter still eludes us but this book is an important milestone to its undoubted eventual elucidation.

Parts of the translations from the Russian are imperfectly idiomatic, but scarcely troublesomely so. The political bias of the Communist writers leaves only faint traces. Michurin is referred to (p. 381) in noting the incomplete role of chromosomes in heredity, and Engles' name appears four times.

The Meaning of Wilderness to Science.

Edited by DAVID BROWER. 1960. Sierra Club, San Francisco. 130 pp., 48 pp. of photographs. \$5.75.

"By the side of religion, by the side of science, by the side of poetry and art, stands Natural Beauty, not as a rival to these, but as the common inspirer and nourisher of them all, and with a secret of her own beside. . . . It is the highest common denominator in the spiritual life of today."—G. M. Trevelyan in Brower's *The Meaning of Wilderness to Science*.

In this age of atomic energy, of intercontinental missiles, and of marvelous medical advances, it is too easy to forget that the principal importance of nature is that its enjoyment gives man one of his main reasons for being. The Sierra Club of San Francisco is composed of persons dedicated to the appreciation and preservation of natural beauty as represented by wilderness areas, and this beautiful, thoughtful, and stimulating book has been published by them to further this objective. It consists of nine or ten papers most of which were presented at the Sixth Biennial Wilderness Conference in San Francisco, March 20 and 21, 1959. They treat of the promo-

tion of a wider public appreciation of wilderness, the importance of wilderness in promoting research on the interrelationships of living things, and the threats which a rampant commercialism and the present world wide population explosion present to its preservation. What chance, we are asked, is there that the resurgent peoples of Africa, pushed as they will be by the problems of mere sustenance, will preserve the wildlife refuges that the white "imperialists" are trying to establish? Even the white "natives" of Alaska, in the person of Senator Bartlett, are resisting adequate wildlife preserves in the 49th state. The 48 exquisite pages of Alaskan landscapes and wildlife are a notable feature of the book. Its perusal is recommended to all who love nature and would aid in its study and preservation.

Anatomy of Seed Plants. KATHERINE

ESAU. 1960. John Wiley and Sons, New York. 376 pp., illus. \$6.95.

This is a text for a one semester course in plant anatomy. It is about half as long as the author's 1953 *Plant Anatomy*. Though independent of the longer book, the author admits that one of her motives for writing it was "to bring the subject matter up to date." Furthermore, the bibliographies are supplemental to rather than inclusive of those in the 1953 work.

The book is developed along logical classical lines: 2 chapters (22 pages) on embryology and development; 10 chapters (141 pages) on tissues, ending with secretory structures; and 9 chapters (166 pages) on plant organs, terminating with separate chapters on the flower, the fruit, and the seed. The book concludes with a 28 page glossary and an index.

Animal Species and Their Evolution. A. S.

CAIN. 1960. Harper & Bros., New York. 190 pp., illus. \$1.35.

Since its original publication in 1954, this book has come to be recognized as one of the best and most lucid introductory statements of the species problem. Its issue now as one of the Harper Torchbook Science Library series will increase its circu-

lation among zoologists and others interested in its problem. The morphological species, the geographically polytypic species, the biological species or interbreeding population, and the agamospecies reproducing asexually or parthenogenetically are passed in review with numerous examples, usually but not always drawn from birds. The last two chapters give the author's reasons for regarding geographical isolation as the only method of species differentiation. A brief reading list concludes the book. Unfortunately, the author does not include references to several of the important books and papers referred to in his text; e.g., Wagner 1868, 1870, 1875; Wright 1931; Fisher 1930; Gause 1934.

Frontiers of the Sea. The Story of Oceanographic Exploration. ROBERT C. COWEN. 1960. Doubleday & Co., Inc., Garden City, N. Y. 307 pp., 54 figs., 16 plates. \$4.95.

Mr. Cowen is the natural science editor of *The Christian Science Monitor*. In this interesting book he covers in discriminating fashion the whole field of oceanography. The development of oceanographic exploration, the geological origins of the ocean, the ocean floor, ocean currents and waves, and the role of the oceans in distributing heat from the sun, the ocean as the abode of living things, and the ocean as the present and future sources of food are all discussed. The book is an introduction for non specialists. The biologist will go to it for general background, but he will consult more elaborate references for biological information. There is a bibliography for further reading.

Beekeeping. JOHN E. ECKERT and FRANK R. SHAW. 1960. Macmillan. New York. 1960. 536 pp., 150 figs. \$12.50.

This attractive volume is published as a successor of *Beekeeping* by Everett F. Phillips. It is designed to deal with all phases of beekeeping in a manner that can be used either as a text in organized classes or for reference by the beginner or commercial beekeeper. Three-fourths or so of the book

is devoted to practical procedures in the management of bees, but the basic facts of bee biology are presented briefly. An initial chapter and a chronological appendix outline the history of beekeeping and a concluding chapter and a 45-page bibliography give an idea of the essential literature. A 14-page glossary explains some of the special terms used, but the reviewer noted the readiness with which the procedural portions of the book fall into a beekeepers' jargon which is only incompletely clarified by the glossary. Both authors have had long experience with apiculture so that there is every reason to place full confidence in their suggestions.

An entomologist who, like the reviewer, is not an apiculturist, can only marvel at the many ways in which the relatively rigid instincts of *Apis mellifera* L. can be manipulated for the benefit of the beekeeper.

A Guide Book to the Marine Fishes of Rhode Island. BERNARD L. GORDON. 1960. The Book and Tackle Shop, Watch Hill, R. I. 136 pp., 82 figs. \$4.00.

This book, by a member of Phi Sigma and a contributor to *The Biologist*, is a list of 215 species of marine fishes of Rhode Island with notes on their occurrence, economic importance, and general bibliography. Noteworthy are two tables toward the end of the book. The first is a list of 40 species not mentioned in the 1910 list of fishes from the state. Some of these may be due to more intensive collecting, but the author suggests that a majority are due to an increase in water temperature bringing in southern species. The second is a list of 31 species not found since the 1910 list was published. Some of these are rare or difficultly taken species, like the 5 species of flying fish; some may be adventitious captures not really members of the fauna; some may represent real faunal changes. Both lists serve to remind us that the determination of a fauna is relative to the methods employed in its study, is beset with borderline uncertainties, and is subject to changing conditions. It will be interesting to see what deletions and additions another fifty years will produce.

Reptiles: Life History, Evolution and Structure. ANGUS D'A. BELLAIRS. 1960. Harper & Bros., New York. 192 pp., illus. \$1.35.

This is a fully authoritative but discursive and somewhat pedestrian account of reptiles—their origin from labyrinthodont ancestors, their differentiation including their ultimate production of mammals and birds, their catastrophic but unexplained decline at the end of the Cretaceous, and their surviving forms: the turtles, crocodiles, lizards, and snakes which were remnants of a mighty past, though they still outnumber the living mammals in number of species (p. 11). The account is synoptic and general. Most families and many genera are cited. Many distinguishing characters are alluded to but no attempt is made to give precise definitions of the orders and families—let alone the genera—mentioned. The illustrations are small, even minute, line drawings that are not particularly attractive. A three page bibliography gives essential references, but no titles or precise pagination are given for papers and articles cited. The book is one of the Harper Torchbook Science Library paper backs, a reprint of a book first published in 1957.

Natural Selection in Human Populations. *Symposia of the Society for the Study of Human Biology. Vol. II.* Edited by D. F. ROBERTS and G. A. HARRISON. 1959. Pergamon Press, New York. 76 pp., illus. \$3.00.

These 6 papers are intended more to stimulate the study of natural selection in man than to report established facts. The first, third, and fourth essays, by L. S. Penrose, C. A. Clarke, and P. M. Sheppard, keep close to the book's title with some special reference to "balanced polymorphism" and "heterozygosis," but the fifth essay "On Selection of Gene Systems in Natural Populations" by Dobzhansky concerns flies and not man, the sixth essay on the "Rate of Change in Primate Evolution" by E. H. Ashton has virtually no pertinent facts to report, and the second essay by A. R. G. Owen is concerned only with "Mathemati-

cal Models for Selection." The book will interest geneticists more than general students seeking a summary of what can be said about natural selection in man.

Design for a Brain. The Origin of Adaptive Behavior. W. ROSS ASHBY. 1960. John Wiley & Sons, New York. 2nd Edition. 286 pp., illus. \$6.50.

The author is director of the Burden Neurological Institute, England. In this book he attempts in rigorous logical fashion to deduce the sort of a mechanism required to give the sort of learning behavior exhibited by man and the higher animals. In believing himself to have been successful in this attempt he lends further substantiation to a mechanistic nonvitalistic view of biological phenomena. The results of his investigation should be of interest to biologists, psychologists, and philosophers concerned with understanding human behavior.

Results of cosmological import emerge toward the end of the study. "The development of life on earth," and hence on any somewhat similar astronomical body, "must thus *not* be seen as something remarkable. . . . It was inevitable in the sense that if a system as large as the surface of the earth, basically polystable, is kept gently simmering dynamically for five thousand million years, then nothing short of a miracle could keep the system away from those states in which the variables are aggregated into intensely self-preserving forms" (p. 233) first giving adapted "gene patterns" and then "learning mechanisms." And may not human-type reason itself be an equally inevitable outcome? Life and reason are not, then, accidental, but an integral part of cosmic processes, probably of repeated occurrence in the universe.

Source Book of Medical History. Edited by LOGAN CLENDENING. 1960. Dover Publications, New York. 685 pp. \$2.75.

Classics of Medicine and Surgery. Edited by C. N. B. CAMAC. 1959. Dover Publications, New York. 435 pp., 9 portraits. \$2.25.

Experiments and Observations on the Gastric Juice and the Physiology of Digestion. WILLIAM BEAUMONT. With an introductory essay by WILLIAM OSLER. 1959. Dover Publications, New York. XI + 280 pp., illus. \$1.50.

Every historian of science and every student or practitioner of medicine who looks at his profession as more than simply a means to earn a living will value these inexpensive reprints of great documents in the development of the science and art of medicine.

The first consists of 139 extracts from some 118 authors and are perforce brief. Twenty-one pages from Hippocrates, 11 pages from Galen, 24 pages from Vesalius, 13 pages from Harvey, and the original descriptions of Hodgkin's, Addison's, and Parkinson's diseases exemplify the sorts of things the book contains.

The second book consists of reprints of entire works: Lister on antiseptic surgery, Harvey on blood circulation, Auenbrugger on percussion of the chest, Laennec on auscultation and the stethoscope, Jenner on smallpox (3 essays), Morton and Simpson, separately, on anaesthesia, and Holmes on puerperal fever. Each essay is prefaced by a biographical sketch of its author.

The final volume is a facsimile reprint of the first edition of 1833 of William Beaumont's observations and experiments on the physiology of the stomach of one Alexis St. Martin, aet. 18 years, who, on June 6, 1822 on Mackinac Island, Michigan, suffered a gun shot wound that healed in such a fashion as to leave a permanent fistula into the stomach about $2\frac{1}{2}$ inches in circumference. Beaumont, an army surgeon, had St. Martin under observation intermittently for about 10 years (St. Martin died in 1887 at the age of 90 years) and made many of the first precise observations on the physiology of gastric digestion.

Vitamin B₁₂. E. LESTER SMITH. 1960. Methuen & Co., London,—John Wiley & Sons, New York. 196 pp. \$3.00.

Vitamin B₁₂, C₆₃H₈₈O₁₄N₁₄PCo, is a substance synthesized by certain microorganisms which is essential for the growth and health of man and animals. It is concentrated in the liver and is efficacious in treating pernicious anaemia. This little volume, one of Methuen's Monographs on Biochemical Subjects, treats of the isolation, molecular structure, absorption, physiological action, and therapeutic value of Vitamin B₁₂.

CHAPTERS FOUNDED

ALPHA—Ohio State University, Columbus, Ohio, 17 March 1915.

BETA—University of Michigan, Ann Arbor, Michigan, 3 June 1916.

GAMMA—North Dakota Agricultural College, Fargo, North Dakota (1916).

DELTA—University of Maine, Orono, Maine, 27 January 1917.

EPSILON—University of Denver, Denver, Colorado, 5 March 1917.

ZETA—University of Wisconsin, Madison, Wisconsin, 30 May 1917.

ETA—University of Akron, Akron, Ohio, 20 April 1921.

THETA—Michigan State College, Lansing, Michigan, 9 April 1921.

IOTA—Washington University, St. Louis, Missouri, 28 May 1921.

KAPPA—University of Kansas, Lawrence, Kansas, 31 May 1921.

LAMBDA—University of Montana, Missoula, Montana, 4 May 1921.

MU—University of California, Berkeley, California, 27 April 1922.

NU—Washington and Jefferson College, Washington, Pennsylvania, 11 May 1922.

XI—University of Nebraska, Lincoln, Nebraska, 3 May 1924.

OMICRON—University of North Dakota, Grand Forks, North Dakota, 26 May 1924.

PI—Emory University, Georgia, 3 January 1925.

RHO—University of Illinois, Urbana, Illinois, 28 March 1925.

SIGMA—University of Florida, Gainesville, Florida, 4 December 1925.

TAU—Duke University, Durham, North Carolina, 4 March 1926.

UPSILON—Miami University, Oxford, Ohio, 7 May 1926.

PHI—University of New Hampshire, Durham, New Hampshire, 21 May 1926.

CHI—Montana State College, Bozeman, Montana, 11 February 1927.

PSI—University of Washington, Seattle, Washington, 7 April 1928.

OMEGA—University of Oklahoma, Norman, Oklahoma, 24 March 1928.

ALPHA ALPHA—University of Southern California, Los Angeles, California, 17 May 1928.

ALPHA BETA—Mount Union College, Alliance, Ohio, 17 May 1928.

ALPHA GAMMA—University of South Dakota, Vermillion, South Dakota, 15 May 1928.

ALPHA DELTA—Lawrence College, Appleton, Wisconsin, 17 March 1929.

ALPHA EPSILON—University of Pittsburgh, Pittsburgh, Pennsylvania, 23 March 1929.

ALPHA ZETA—College of William and Mary, Williamsburg, Virginia, 19 April 1930.

ALPHA ETA—Oklahoma State University, Stillwater, Oklahoma, 13 March 1930.

ALPHA THETA—State College of Washington, Pullman, Washington, May 1930.

ALPHA IOTA—Bucknell University, Lewisburg, Pennsylvania, 9 January 1932.

ALPHA KAPPA—Hunter College, New York City, 8 January 1932.

ALPHA LAMBDA—University of Utah, Salt Lake City, Utah, 13 February 1932.

ALPHA MU—University and State College of Oregon, Eugene-Portland-Corvallis, Oregon, 18 November 1933.

ALPHA NU—University of New Mexico, Albuquerque, New Mexico, 21 April 1935.

ALPHA XI—University of Rhode Island, Kingston, Rhode Island, 17 May 1935.

ALPHA OMICRON—Marquette University, Milwaukee, Wisconsin, 18 June 1938.

ALPHA PI—University of Colorado, Boulder, Colorado, 24 May 1941.

ALPHA RHO—University of Arkansas, Fayetteville, Arkansas, 23 May 1945.

ALPHA SIGMA—University of Texas, Austin, Texas, 2 February 1946.

ALPHA TAU—National University of Mexico, Mexico, D.F., 7 April 1947.

ALPHA UPSILON—University of California at Los Angeles, California, 17 May 1947.

ALPHA PHI—College of Puget Sound, Tacoma, Washington, 28 February 1948.

ALPHA CHI—University of the Philippines, Manila, Luzon, P.I., 12 March 1949.

ALPHA PSI—Virginia Polytechnic Institute, Blacksburg, Virginia, 24 May 1949.

ALPHA OMEGA—University of Georgia, Athens, Georgia, 17 May 1951.

BETA ALPHA—Pennsylvania State Univ., State College, Pennsylvania, 26 May 1955.

BETA BETA—Florida State University, Tallahassee, Florida, 18 February 1956.

BETA GAMMA—Long Island University, Brooklyn N. Y., 27 April 1957.

BETA DELTA—University of Virginia Charlottesville, Virginia, 22 March 1958.

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